COMMUNICATION SYSTEM AND METHOD THEREFOR

Field of the Invention

The present invention relates to a communication system with a network communicating with subscriber units over radio channels. The invention is applicable but not limited to a cellular communication system such as the Global System for Mobile communication (GSM) or the Universal Mobile Telecommunication System (UMTS) currently under standardisation.

Background of the Invention

In a cellular mobile communication system, each of the subscriber units communicate with typically a fixed base station. Communication from the subscriber unit to the base station is known as uplink and communication from the base station to the subscriber unit is known as downlink. The total coverage area of the system is divided into a number of separate cells each covered by a single base station. The cells are typically geographically distinct with an overlapping coverage area with neighbouring cells. As a subscriber unit moves from the coverage area of one cell to the coverage area of another cell, the communication link will change from being between the subscriber unit and the base station of the first cell to being between the subscriber unit and the base station of the second cell. This is known as a handover. Specifically, some cells may lie completely within the coverage of other larger cells.

All base stations are interconnected by a network. This network comprises communication lines, switches, interfaces to other communication networks, various controllers required for operating the network and the base stations themselves. A call from a subscriber unit is routed through the network to the destination specific for this call. If the call is between two subscriber units of the same communication system the call will be routed through the network to the base station of the cell in which the other subscriber unit is currently located. A connection is thus established between the two serving cells through the network. Alternatively, if the call is between a subscriber unit and a telephone connected

to the Public Switched Telephone Network (PSTN) the call is routed from the serving base station to the interface between the cellular mobile communication system and the PSTN. It is then routed from the interface to the telephone by the PSTN.

A cellular mobile communication system is allocated a frequency spectrum for the radio communication between the subscriber units and the base stations. This spectrum must be shared between all subscriber units simultaneously using the system. In GSM and similar systems this is achieved by dividing the spectrum into a number of frequency channels. In GSM each of the frequency channels are furthermore divided into eight distinct time slots. By allocating a time slot to each active subscriber unit eight subscriber units can thus be served by each frequency channel. Each cell is allocated a number of frequency channels. As the number of frequency channels are limited, the same frequency channels are typically allocated to more than one cell. This is known as frequency re-use and the tighter the frequency reuse, i.e. the closer together the same frequency channel can be used, the higher is the achievable traffic capacity of the system.

As the demand for wireless mobile communication increases, efficient use of the limited resources becomes increasingly important. In addition a greater variety in services are envisaged with specifically the need for a variety of data services being of increasing importance. The Universal Mobile Telecommunication System (UMTS) under development is intended to provide many different services including data services of varying data rate, delays and error rates. The system is expected to be used for very different applications including both high priority time critical applications requiring immediate and fast resource allocation as well as low priority applications which are not time critical.

Current systems typically provide a static resource allocation where the available resource is allocated to the base stations for an extensive period of time. When communication is required from a subscriber unit, it will request resource from the network. If any is available it will be allocated to the subscriber unit and the call will proceed. However, if none is available the call will be blocked and cannot proceed.

As a consequence of the variety of services the resource requirements will fluctuate substantially in future mobile communication systems. In order to ensure a sufficiently low blocking rate, each base station will need a high resource allocation which will only be used during periods of peak loading. A lower resource allocation to the base stations results in high blocking rates and thus poor service to the user.

A significant advantage can thus be gained from reduction of the fluctuations in resource requirements.

Summary of the Invention

The invention seeks to provide a system for reducing resource fluctuations and providing better user service in a communication system with a network communicating with subscriber units.

According to a first aspect of the invention, there is provided a communication system including a communication network performing at least one communication with at least one subscriber unit over a radio communication link, the communication system having a plurality of different characteristics and comprising means for transmitting dynamic system information relating to the status of the communication system from the communication network to the at least one subscriber unit, and the at least one subscriber unit comprising means for receiving the dynamic system information and means for selecting a preferred value of at least one characteristic of the communication system in response to the dynamic system information, and means for setting the at least one characteristic of the communication system to said preferred value of the at least one characteristic.

Preferably, the dynamic system information is broadcast to the subscriber units and contains one or more of the following parameters:

a) a traffic load,

b) a resource allocation,

c) a traffic mix,
d) the location of the subscriber units,
e) the capabilities of subscriber units active in the system,
f) the capabilities of the network,
g) the available resources of the network,
h) a tariff,
i) availability of service providers,
j) capability of service providers,
k) availability of other communication systems,
l) capability of other communication systems, and
m) available services.

Preferably the subscriber unit modifies the time of communication, the communication needs or the communication format.

According to a preferred feature of the invention, the subscriber unit comprises means for presenting the dynamic system information to and receiving input from a user or an external device.

According to a different preferred feature, the subscriber units further comprise means for requesting the network to change an operating characteristic of the communication system and the network comprises means for changing the operating characteristic in response to said request.

According to a second aspect of the invention, there is provided a method of modifying communication in a communication system including a communication network performing at least one communication with at least one subscriber unit over a radio communication link, the communication system having a plurality of different characteristics, said method being characterized by comprising the steps of transmitting dynamic system information relating to the status of the communication system from the communication network to the at least one subscriber unit, and receiving the dynamic system information and selecting a preferred value of at least one characteristic of the

communication system in response to the dynamic system information at the at least one subscriber unit, and setting the at least one characteristic of the communication system to said preferred value of the at least one characteristic.

Brief Description of the Drawings

An embodiment of the present invention is described below, by way of example only, with reference to the accompanying drawing, in which:

FIG. 1 is an illustration of a cellular communication system to which the invention can be applied.

FIG. 2 illustrates a code tree used in Code Division Multiple Access communication systems such as UMTS.

FIG. 3 is a block diagram of an embodiment of the invention wherein a subscriber unit is connected to an external device.

Description of a Preferred Embodiment

FIG. 1 illustrates a cellular communication system 100. In the system, a base station 101 communicates with a number of subscriber units 103 over radio communication links 105. In the described embodiment the subscriber units 103 are specifically mobile stations. In the cellular system, the base station 101 covers users within a certain geographical area 107 whereas other geographical areas 109, 111 are covered by other base stations 113, 115. Typically, each of the base stations 101, 113, 115 contain a broadcast carrier plus one or more traffic carriers. A broadcast transmission is transmitted indiscriminately to all mobiles and can be received by all mobiles within the coverage area.

In an embodiment of the invention, dynamic system information relating to the current status of the communication system is continuously broadcast to all the subscriber units from the base stations. The subscriber units receives and demodulates this dynamic system information and will control elements of its communication depending on the information received. Alternatively, a predicted future status of the communication system can be broadcast instead of or as well as the current status.

As a specific example, the tariff for a service may vary dynamically depending on the traffic loading of the system. Services will thus be more expensive during periods of high loading than during low loading when resource remains unused. The loading will vary continuously and the tariff can be related to the instantaneous loading and hence also vary continuously. The current tariff will be broadcast to all subscriber units and the individual subscriber unit will thus have information on the current tariff for a service. Depending on how time critical the communication is, the subscriber unit can choose to delay communication to a time when the tariff is below a certain threshold or can choose to transmit instantly but at higher cost.

In most situations, the current traffic mix of a mobile communication system will be varied and include both users with time critical and users with non-time critical applications. An embodiment as described will reduce the fluctuations in the accumulated resource requirement as the tariff during peak periods will increase causing a number of subscriber units to shift their communication to periods of low usage, thereby preventing blocking of the time critical communications during the peak period.

Contrary to a static definition of peak and off-peak periods where for example reduced tariffs are introduced outside office hours, the described embodiment of the invention provides a dynamic adaptation of the traffic mix to the available resource. As a consequence, a more flexible utilisation of resource is obtained with delays for non-critical communications being reduced substantially.

According to a different embodiment of the invention, the transmitted dynamic system information contains the current resource allocation. In a Code Division Multiple Access

(CDMA) communication system the subscriber units use the same frequency spectrum and are distinguished by the spreading codes allocated to the subscriber units. In a CDMA system such as UMTS under standardisation, a number of spreading codes are allocated to each base station. A base station will thus have a maximum number of spreading codes allocated which limits the maximum number of users at the lowest data rate for each base stations. A user transmitting at a higher data rate will be allocated a plurality of spreading codes or can alternatively be allocated a code with lower spreading ratio.

FIG. 2 illustrates a code tree 200. Each vertical branch in the tree corresponds to a spreading code which can be allocated. The length of each spreading code is doubled for each vertical step down in the tree. For a given spreading code the dependent codes, i.e. the lower branches connected to the vertical branch of the given code, are not orthogonal to the parent code. Allocation of a given code thus prevents sufficient separation by any dependent code. In the example of FIG. 2 allocating code 1 to a high rate subscriber unit prevents code 3 and code 4 being utilised. For a multirate CDMA system as described the current code tree 200 indicating which codes are used and which are not used can thus be included in the dynamic system information.

It will be apparent to the person skilled in the art how the dynamic system information can be transmitted to and received by the subscriber units. Specifically, it can be achieved in the same manner as control channels are currently transmitted in cellular systems, such as for example by the information being transmitted on a separate frequency channel, being time multiplexed with other transmissions from the base stations or being allocated a separate spreading code in a Code Division Multiple Access system.

The means for determining and modifying a characteristic of the communication is preferably implemented as a software program running on a suitable processor such as a micro controller or a digital signal processor. Preferably memory units are included to buffer data to be transmitted at later time.

The dynamic system information transmitted by the base station will depend on the implementation of the communication system employing the current invention. It can be a

simple tariff as in the embodiment presented above or can contain detailed information on many aspects of the status of the communication system. Specific examples of information that can be included in the transmitted dynamic system information include the following:

a) A traffic load. The network can transmit information of the current loading of the network. Specifically, this information can be given as a percentage of the total resource currently being used or as the number of users currently active.

b) A resource allocation. Information on how the available resource is allocated can be included in the dynamic system information. Specifically, information on the available resource at each individual base station can be transmitted to the subscriber units. For a CDMA system this is preferably by including the code tree 200 in the dynamic system information as mentioned above. For a Frequency Division Multiple Access (FDMA) or a Time Division Multiple Access (TDMA) system this is preferably achieved by including information on which time slots and frequencies are occupied.

c) A traffic mix. The base stations can transmit information on the current traffic mix such as how many subscriber units are active and which services they are currently using.

d) The location of subscriber units. Information on the location of the mobiles accessing the network can be transmitted including information on the number of subscriber units in various cells. A subscriber unit wishing to access the network will typically access the best serving cell which is normally the closest base station. However, if information is received that there is a large number of subscriber units within this cell whereas very few subscriber units are located in a neighbouring cell, it can choose to access this cell instead of the best serving cell.

e) The capabilities of subscriber units active in the system. In communication systems providing a number of different services, such as UMTS, different subscriber units can have different capabilities. Some subscriber units may thus only be able to support a low data rate transmission whereas other subscriber units are also able to

support high data rate services which consume more resource. This information can be included in the dynamic system information transmitted to the subscriber units.

f) The capabilities of the network. Similarly, the network can have different capabilities for example due to different base stations having different capabilities. In a situation where a base station in a first cell can support high data rate transmission whereas a base station in a neighbouring cell cannot, a subscriber unit can in response to information of this determine which base station can meet the current needs.

g) The available resources of the network. The network will have limited resources other than the limitations imposed by the limited frequency band available for the radio communication between the subscriber units and the base stations. An example is the buffering capability for non critical data services. By including this information, the subscriber unit can modify the communication in response to the currently available resources for example by delaying transmissions until the buffers in the network are sufficiently empty to allow buffering of the entire block of data which is to be transmitted.

h) Availability and capability of service providers. In a mobile communication system such as the GSM system there are typically different service providers which use the same communication system. These service providers may provide different services to the users and information on which service providers currently provide which services in which areas can be included in the dynamic system information. In a situation where for example one service provider cannot provide a high data rate service because the resource is used by other subscriber units, a subscriber unit can in response to this information change to a different service provider where this service is currently available.

i) Availability and capability of other communication systems. A given area will often be covered by a plurality of communication systems. A subscriber unit associated with more than one communication system will thus be able to choose which communication system to use. Specifically some communication systems, such as envisaged for UMTS and GSM, constitute partner communication systems where a subscriber unit may handover between the two systems and where the coverage in some

areas are only possible through one of the systems. Another example is systems using different frequency bands such as for example GSM operating at 900 MHz and DCS which corresponds to GSM but operates at 1800 MHz. Information on the current availability and capability of other communication systems can be included in the dynamic system information transmitted by the base stations. This can in turn be used by the subscriber units in determining which communication to perform on which communication system.

j) Available services. The services that can be supported by the network can vary according to changes in e.g. traffic loading and traffic mix but also due to changes in the network itself. An example is where components of the network are inoperational due to maintenance or repair and the network therefore only can provide a limited set of services. The available services can furthermore vary between different parts of the network due to e.g. different capacity of the transmission links connecting the components of the network. Information on the currently available services in specific areas can be included in the transmitted dynamic system information. The subscriber units can in response modify their communication needs to suit the available services.

Many characteristics of the communication from a subscriber unit can be modified. These include the following:

a) A time of communication. As mentioned above the subscriber unit can delay the time of the communication until the conditions are suitable. Preferably the subscriber unit will delay communication until the tariff is sufficiently low, the appropriate service is available or the traffic loading is low.

b) The communication needs. In some embodiments the subscriber unit can modify the actual communication needs in response to the received dynamic system information. As a specific example where a block of data representing a picture is to be transmitted the subscriber unit can transmit a highly compressed low quality copy if the tariff is currently high but transmit an uncompressed high quality copy if the tariff is currently very low.

c) A prioritisation of communication. According to this embodiment a subscriber unit will modify the prioritisation of communication in response to the received information. As an example, if a subscriber unit has several communication needs and the dynamic system information contains information that a specific service is only available for a certain duration, the communication requiring this service will have higher priority than communication which does not require this service.

d) A communication format. The subscriber unit can modify a characteristic of the communication in response to the received dynamic system information. An example is where information is received that the serving base station has significant amounts of unused resource which temporarily can be allocated to the subscriber unit at negligible cost. The subscriber unit can modify the modulation scheme used from a bandwidth efficient modulation scheme to a less efficient scheme which in return provides improved error rate performance, thus allowing the transmitted power of the subscriber unit to be reduced. If other subscriber units request resource to be allocated from the base station this can be included in the transmitted dynamic system information and the subscriber unit can return to the more bandwidth efficient modulation scheme. Other characteristics which can be modified include forward error correcting schemes, interleaving and the amount of known data (e.g. training sequences) included in the transmissions.

e) A data rate. The subscriber unit can change the information rate in response to the received dynamic system information. For speech communication the speech compression can be modified dependent on for example the current cost for different data rates. At higher cost higher compression and thus lower data rates will be employed whereas lower compression with higher quality will be used at lower costs. The data rate and quality will thus fluctuate in response to the dynamic system information received resulting in a relatively constant cost.

f) A service provider. A subscriber unit can according to this embodiment change the service provider in response to the dynamic system information for example if the desired service is not offered by the current service provider.

g) A communication system. Similarly the subscriber unit can change to a different communication system in response to the dynamic system information for example if the desired service is not offered by the current communication system.

h) A service. The subscriber unit will according to this embodiment modify the service in response to the received dynamic system information. An example is where a communication is changed from a video communication to a speech communication at reduced data rate in response to received information of an increased cost of the higher data rate services.

j) A handover. The mobile can in response to the received dynamic system information perform a handover. An example is when the dynamic system information contains information that a neighbour base station can support a service which the serving base station cannot. The subscriber unit can in this case hand over to the neighbour base station in order to use this service.

In another embodiment, the dynamic system information is not broadcast indiscriminately to all subscriber units but is transmitted to a specific group of subscriber units. Specifically, different system information can be transmitted to different groups of subscriber units. As an example, a cellular communication system may comprise different user categories with different subscription charges and different services. The current availability and cost of a specific service will only be transmitted to subscriber units in the appropriate categories.

In a slightly different embodiment, the dynamic system information is specifically targeted to each individual subscriber unit for example so that an individual subscriber unit is directly informed of the specific tariff for providing various services to the subscriber unit taking into account the current traffic loading, available resources, capabilities of the base station and the specific subscriber unit and the user category of the user of the specific subscriber unit.

In a different embodiment, the subscriber unit may contain means for presenting the received system information to the user of the subscriber unit. Preferably, a display on the subscriber unit will present the information by text or in a suitable graphical format. The information presented can be all the information received, some of the information received or characteristics derived from the information received.

In another embodiment, the subscriber unit contains means for obtaining a user input and for selecting a preferred value of a characteristic of the communication system by taking this information into account. A specific example is where a numeric keypad on the subscriber unit is used to key in a maximum price for a service. The subscriber unit can then from receiving dynamic information on the current cost for a given data rate choose the maximum data rate below this value. In this embodiment the communication is thus modified taking both the received dynamic system information and the user input into account.

According to a different embodiment of the invention the subscriber unit comprises means for communicating with a functionally or physically external device as illustrated in FIG.3. The dynamic system information is transmitted from a base station 301 to a subscriber unit 303 over a radio communication channel 305. The information is in this embodiment communicated over a communication link 307 to an external device 309.

The external device can in principle be any device not an integral part of the subscriber unit but is preferably a computer or an electronic organiser (e.g. a Personal Digital Assistant -PDA). Alternatively the external device can be a Smartcard, and specifically for cellular systems such as GSM it can be the SIM (Subscriber Identity Module) card that is used for holding subscriber information in these systems.

The communication link 307 is preferably a fixed cable connection with appropriate interfaces built into the subscriber unit and the external device but any other known communication link such as infrared or radio links can be used.

The information transmitted on the communication link 307 can be all the dynamic system information received, some of the information received or characteristics derived from the information received.

According to a different embodiment the subscriber unit contains means for receiving an input from an external device and for selecting a preferred value of a characteristic of the communication system by taking this input into account. An example is the system illustrated in FIG.3 where the communication link 307 is a two way communication link. The external device may in this example receives the dynamic system information through the communication link, process the information and provide an input to the subscriber unit through the same communication link 307.

According to a different embodiment, the subscriber unit can in response to the received dynamic system information select a preferred value of a characteristic of the communication system and request the network to change the characteristic accordingly. In this embodiment the mobile station will determine a preferred value of a characteristic but the control of the actual value of the characteristic remains in the network. Preferably, the subscriber unit can request the network to modify the resource allocation. Specifically the network may in response to requests from subscriber units change the resource allocation between base stations or between the subscriber units. In the former case this can be achieved by allocating more spreading codes for a CDMA system and more frequencies for an FDMA system to the base stations requested by the subscriber units. In the latter case the network may reduce the resource allocated to already active subscriber units if a new subscriber unit prepared to pay a higher tariff requests this.

It will be obvious to the person skilled in the art that the invention is not limited to a cellular mobile communication system but is also applicable to other communication systems including wireless local loop systems or satellite communication systems.